
Smart Antennas and Radio Network Planning - 3G and Beyond

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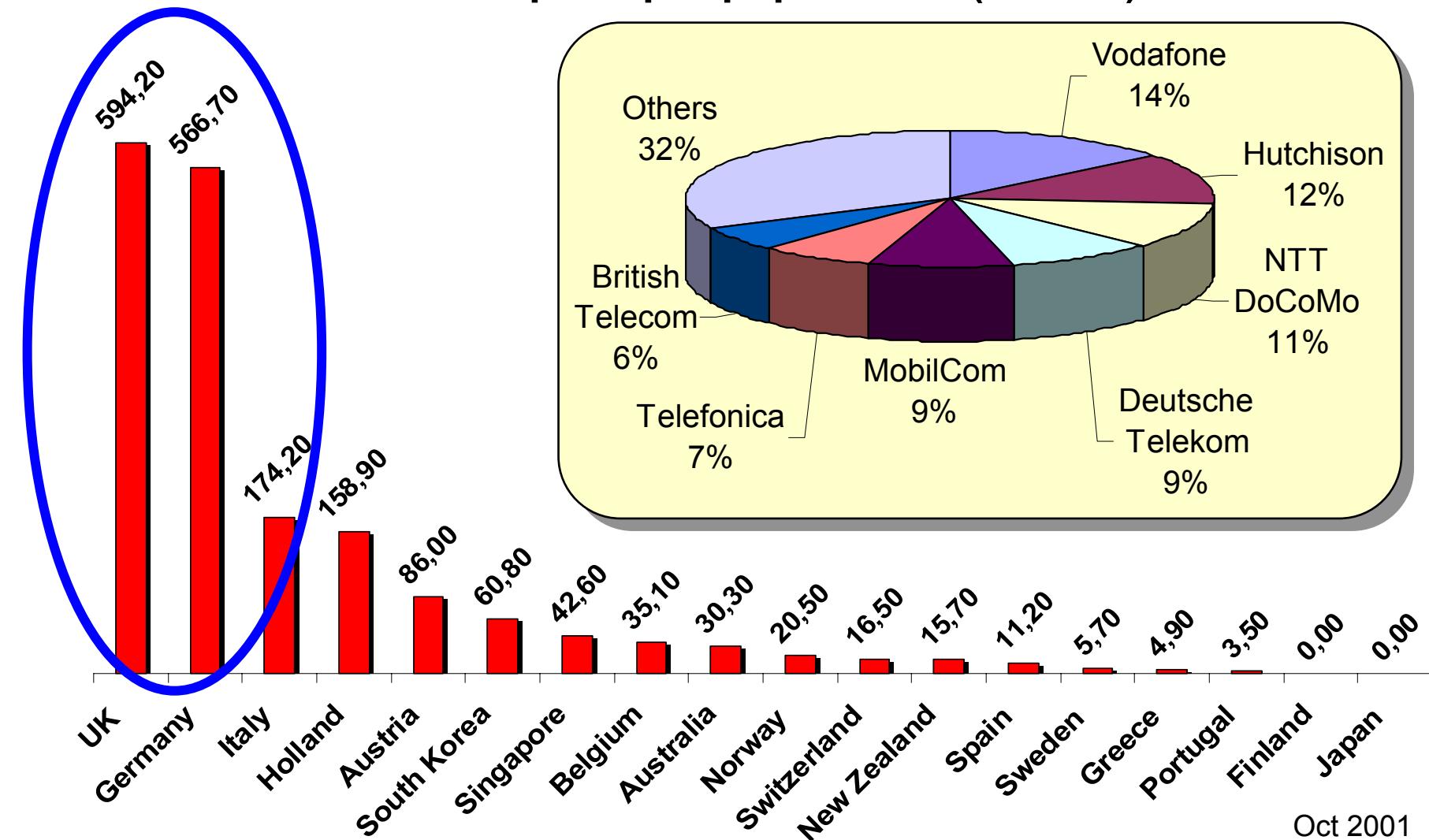
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- **Motivation**
 - Investor's Perspective
 - Time Perspective
 - Implementation
 - **Smart Antenna Planning Targets**
 - **Challenges**
 - **Planning Example - Results**
 - **Considerations beyond 3G**

Investor's Perspective

License price per pop. in \$US (Oct. 01)



- Expensive licenses
- Accrued interest
- Investment in infrastructure
- Many additional sites for the future mobile-data market



Smart Antenna Radio Network
Planning optimizes capital investment

- **Radio Network roll-out**

- How to acquire new sites?
- How to fulfill license conditions (coverage)?



- **Rapid adaptation to the customers need**

- Adapt to future market growth
- Adapt to new services and applications

Smart Antenna Radio Network
Planning **reduces time-to-market**



Implementation

- **2G – 3G – Smart Antennas**

- What can be re-used?
- How to model the radio channel?

- **Multi-Service UMTS**

- How does the max. capacity depend on the service mix?

- **Where to use Smart Antennas?**

- optimized number of smart antennas



Smart Antenna Radio Network Planning
is the **first step towards optimization**

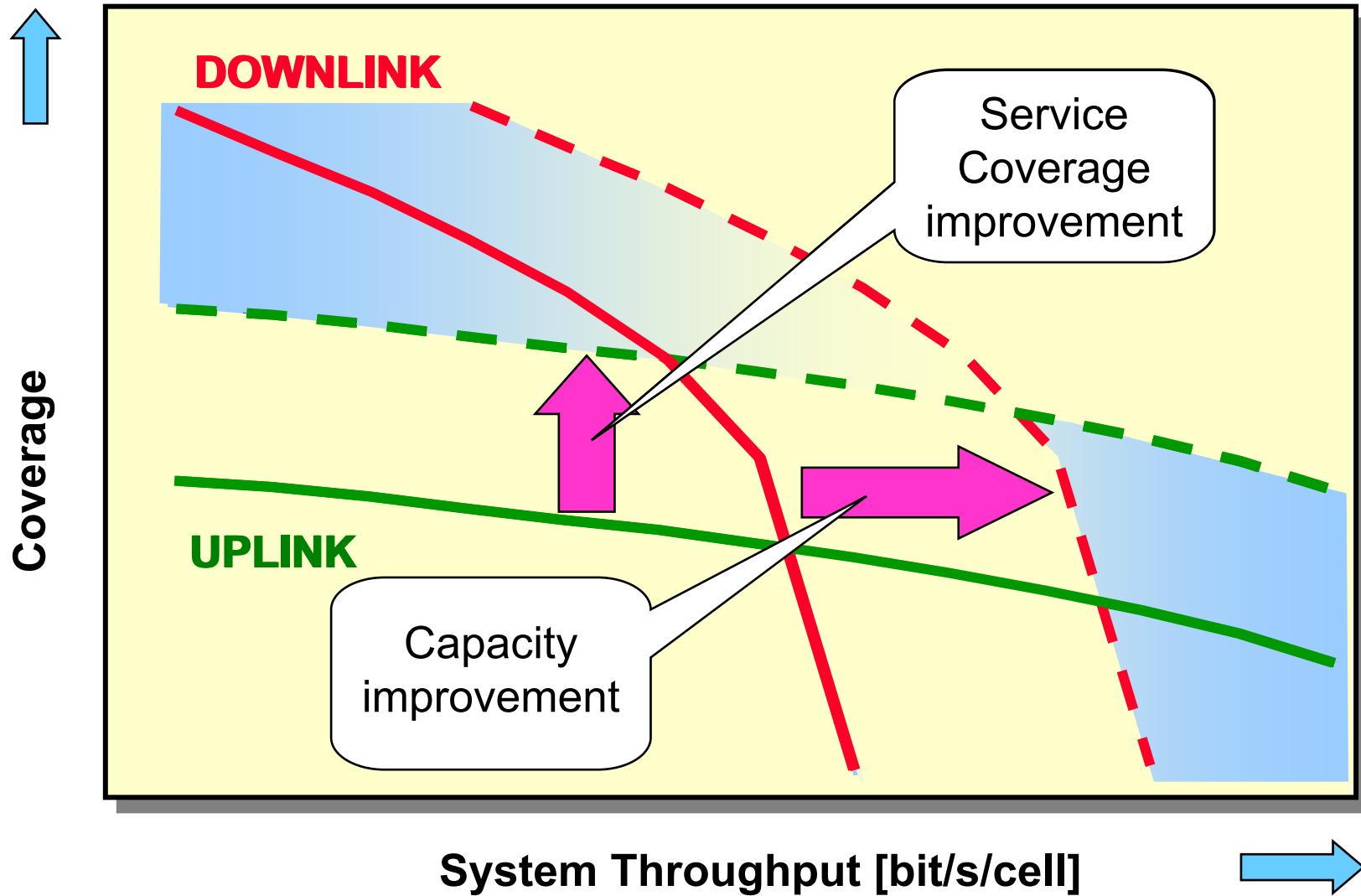
- **Introduction**
- **Smart Antenna Planning Targets**
 - 3G Radio Network Planning Trade-off
 - Smart Antenna Planning Targets
- **Challenges**
- **Planning Example - Results**
- **Considerations beyond 3G**

- Capacity
- Coverage
- Quality of Service (QoS)
- Cost

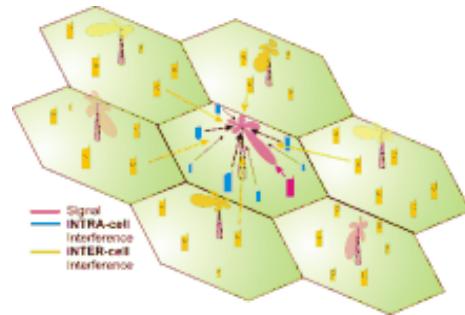
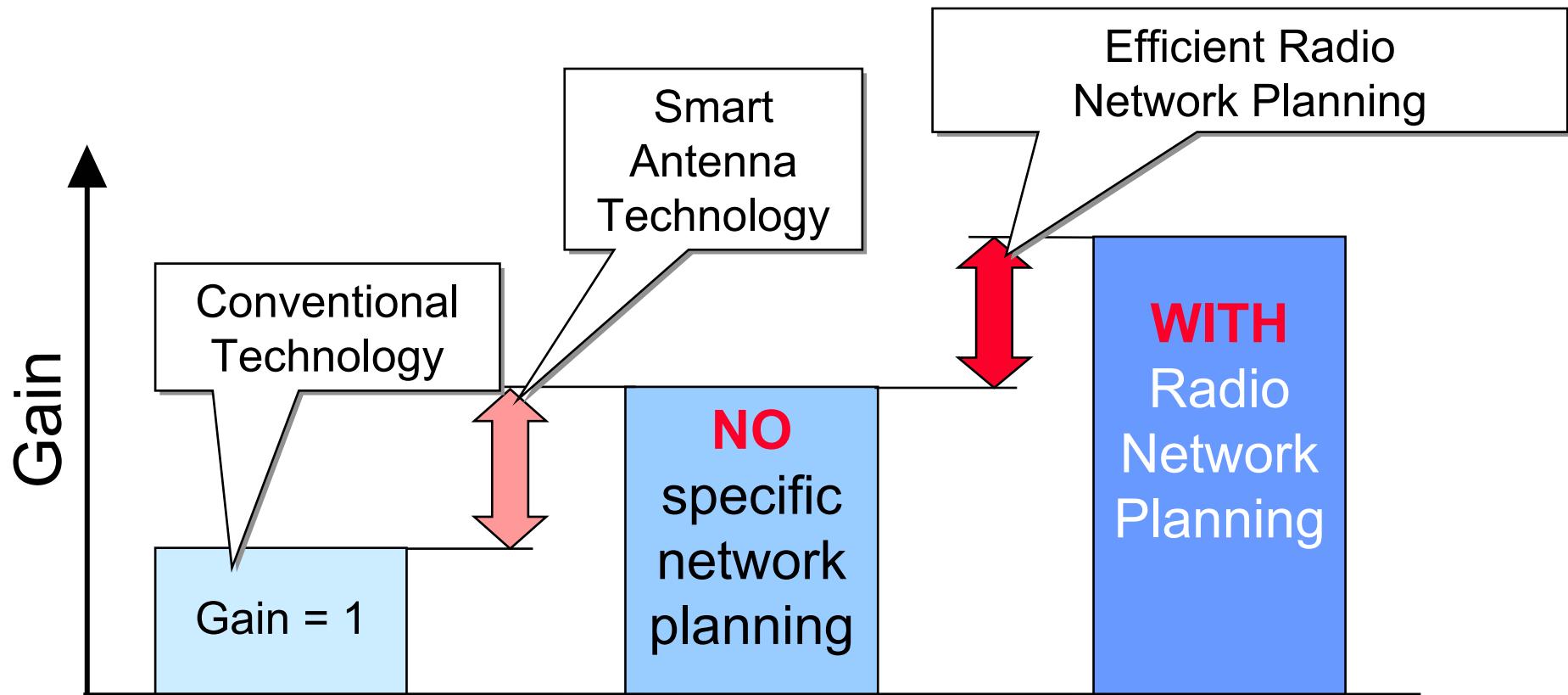
A multi-dimensional, interdependent optimization problem



Effects of Smart Antennas on UMTS Coverage and Capacity



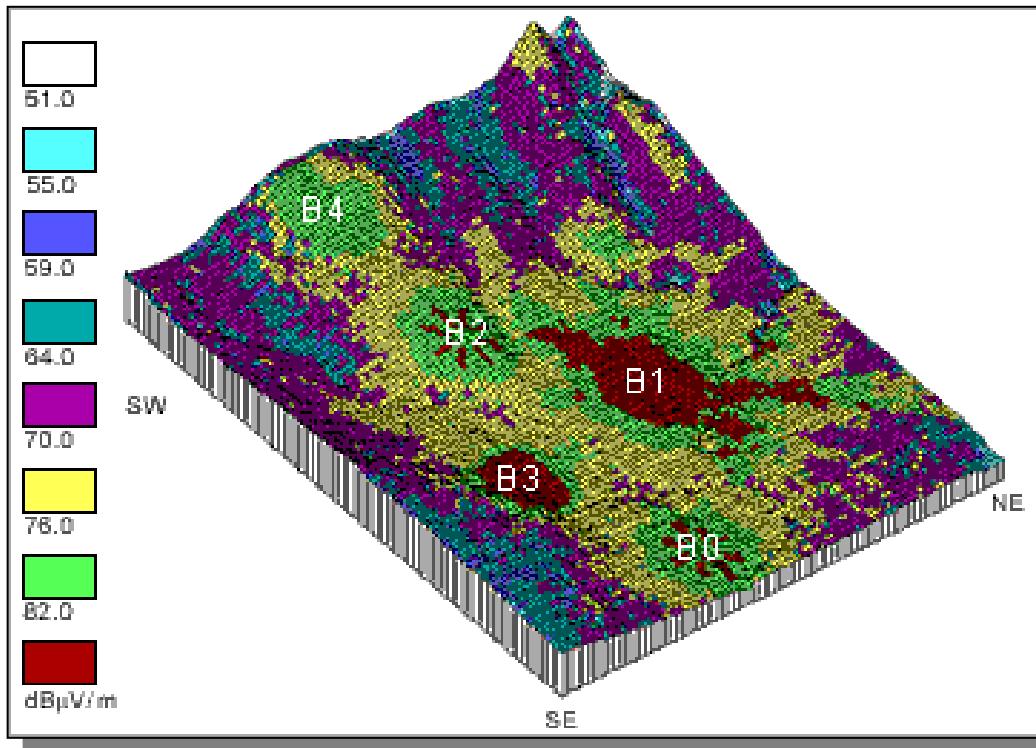
Effects of Smart Antenna Radio Network Planning



- **Introduction**
- **Smart Antenna Planning Targets**
- **Challenges**
 - Channel Models
 - Interference
 - Space-Time Receivers
- **Planning Example - Results**
- **Considerations beyond 3G**

Conventional Channel Models

Terrain data-base



⇒ pathloss

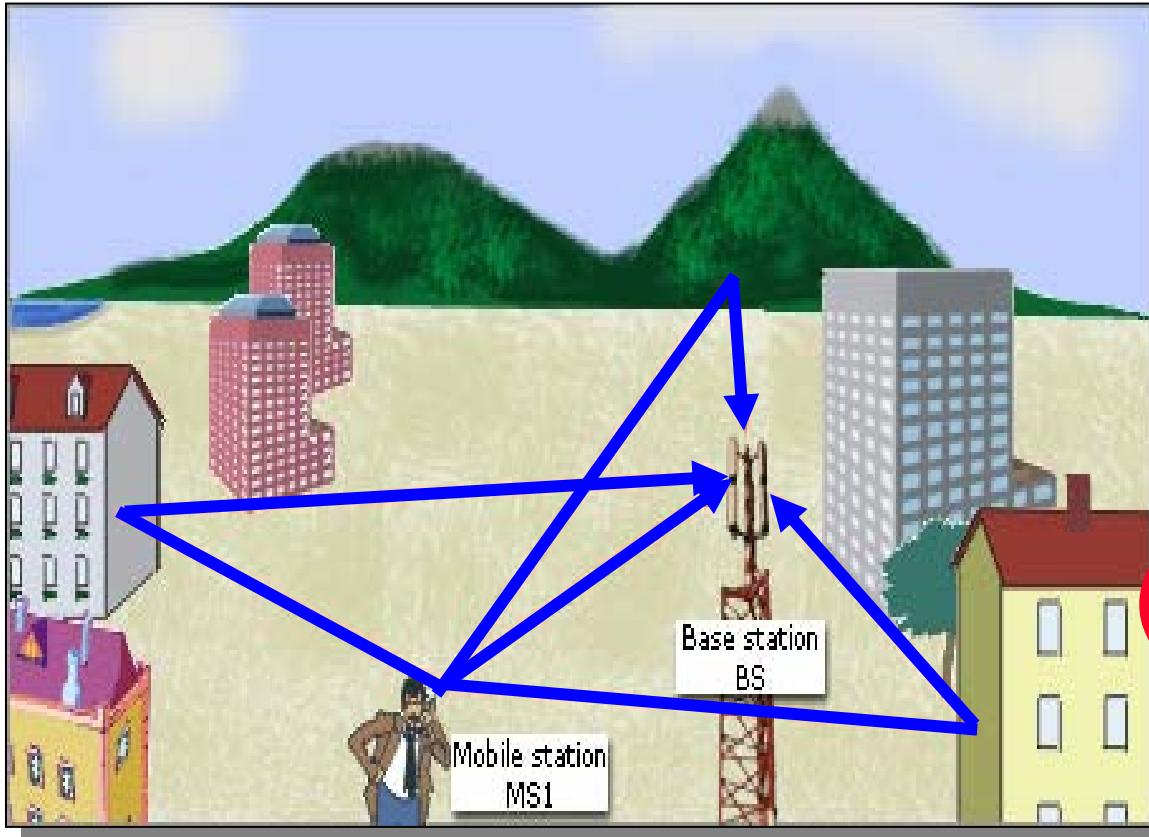
⇒ mean delay

⇒ delay spread

Angular domain?

Conventional models **are not sufficient** for
Smart Antenna implementations

Spatio-Temporal Channel Models

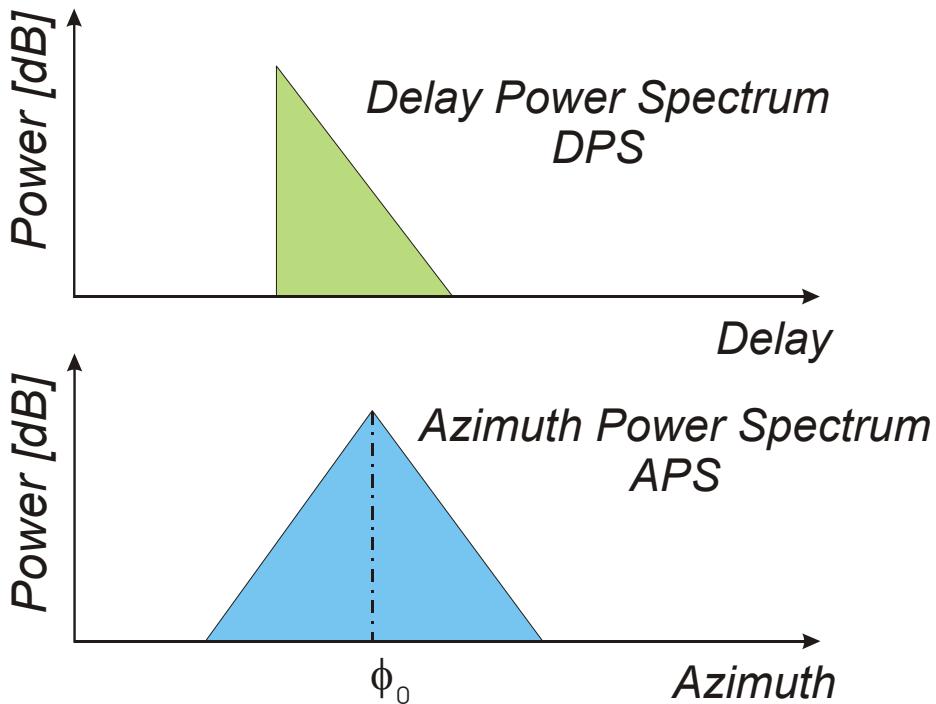


- ⇒ pathloss
- ⇒ mean delay
- ⇒ delay spread
- ⇒ mean DoA
- ⇒ angular spread

Spatio-Temporal models **are necessary** for
Smart Antenna implementations

3GPP - COST 259 Extended Channel Model

Spatio-Temporal
channel characterization



Cell Types

- Macrocell
- Microcell
- Picocell

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Radio Environment

- General Typical Urban
- General Rural Area
- General Hilly Terrain

.....

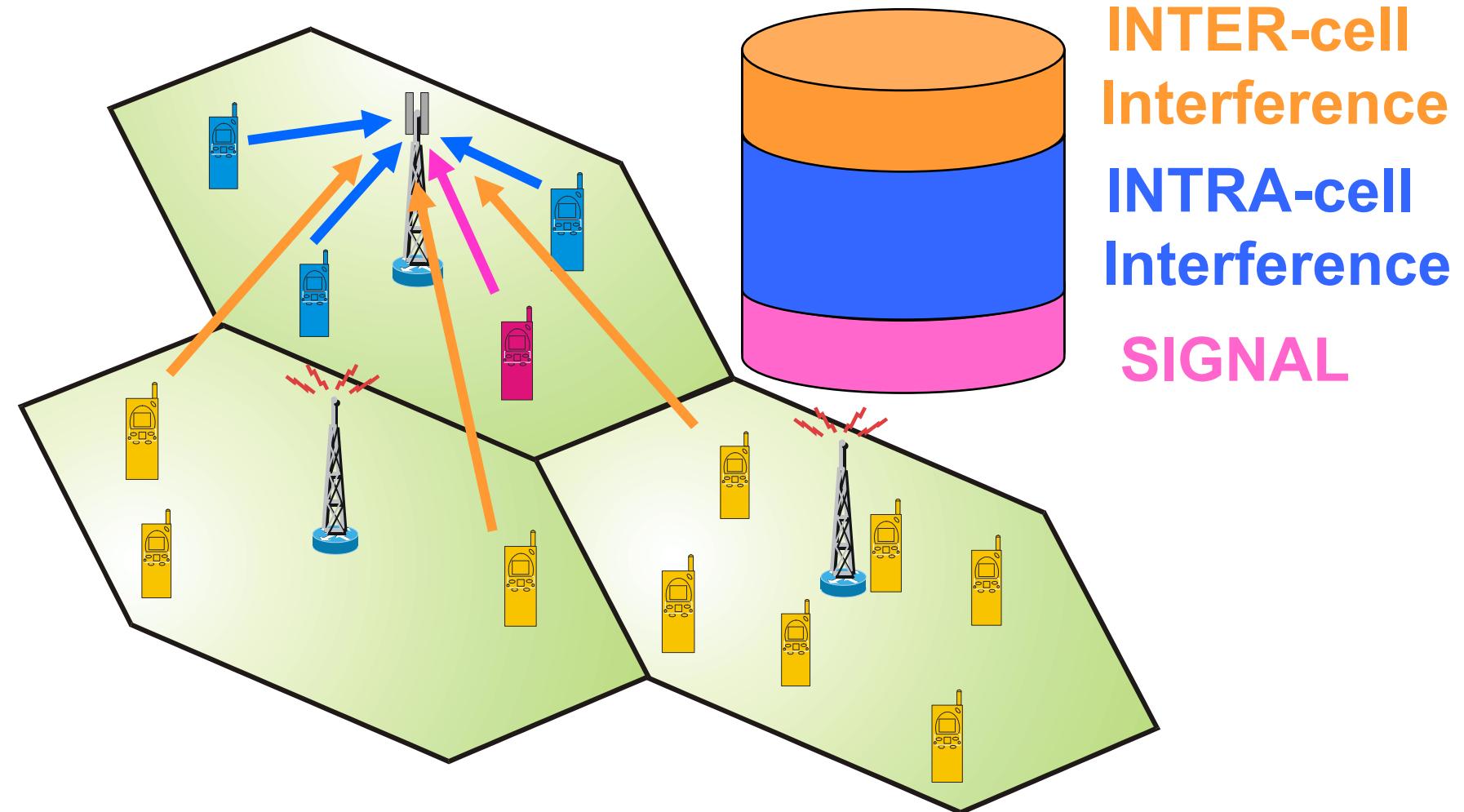
Propagation Scenarios

- local parameters #1
- local parameters #2

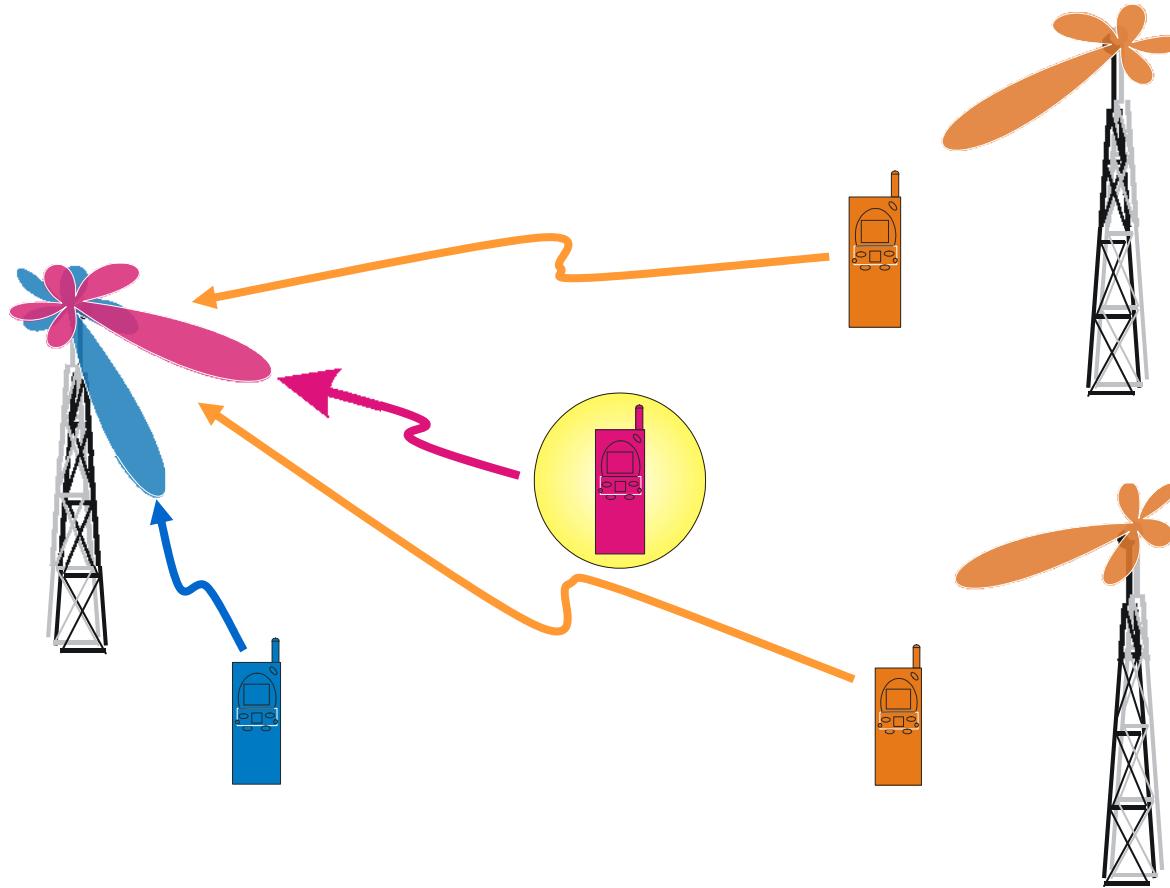
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UMTS is an interference limited system!

Total received power (UL)



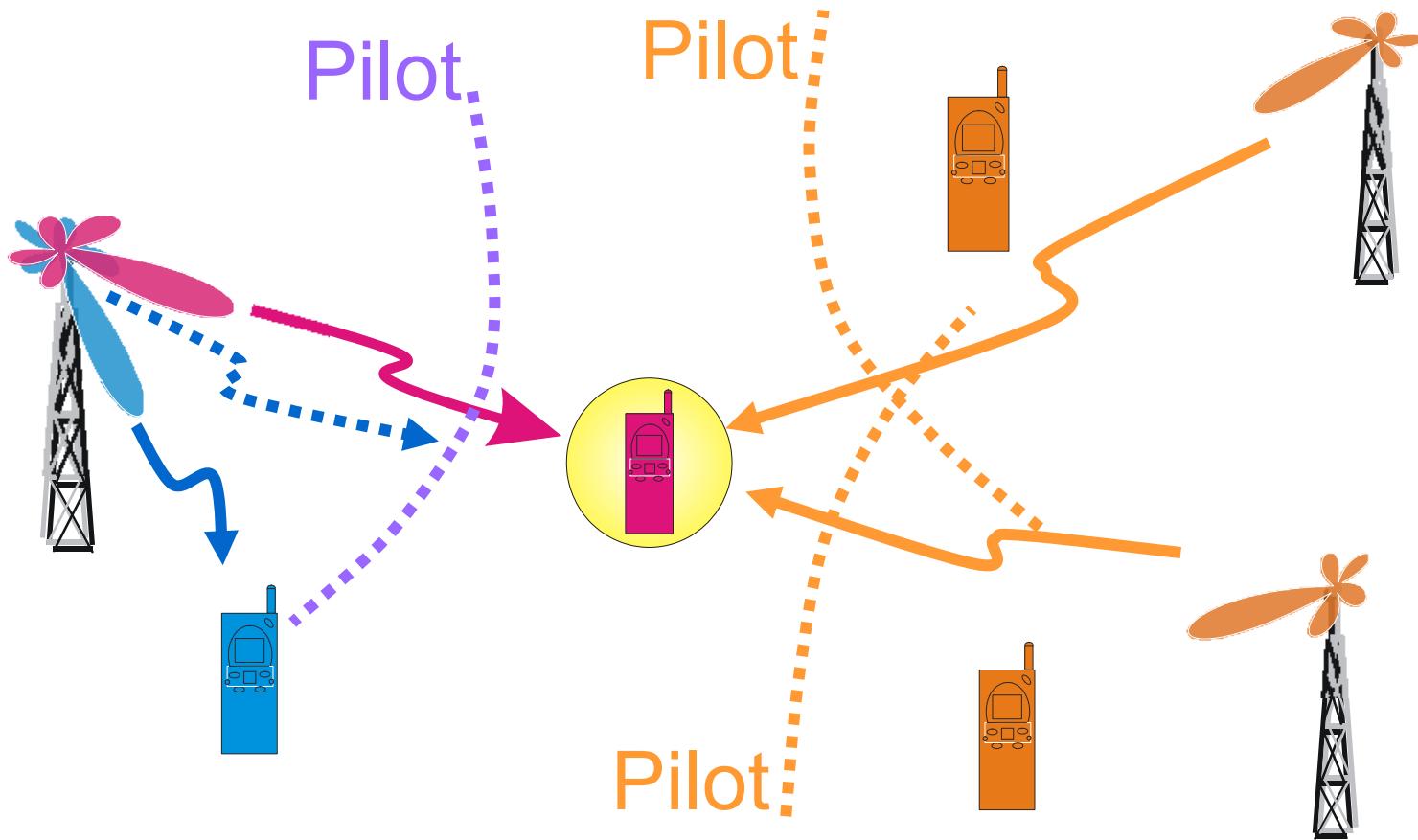
Smart Antenna Interference Situation - Uplink



UPLINK Interference

$$I_{\text{total}} = I_{\text{INTRACELL}} + I_{\text{INTERCELL}} + I_o$$

Smart Antenna Interference Situation - Downlink



DOWNLINK Interference

$$I_{\text{total}} = \beta * I_{\text{INTRACELL}} + I_{\text{INTERCELL}} + I_{\text{Pilot\&Control}} + I_o$$

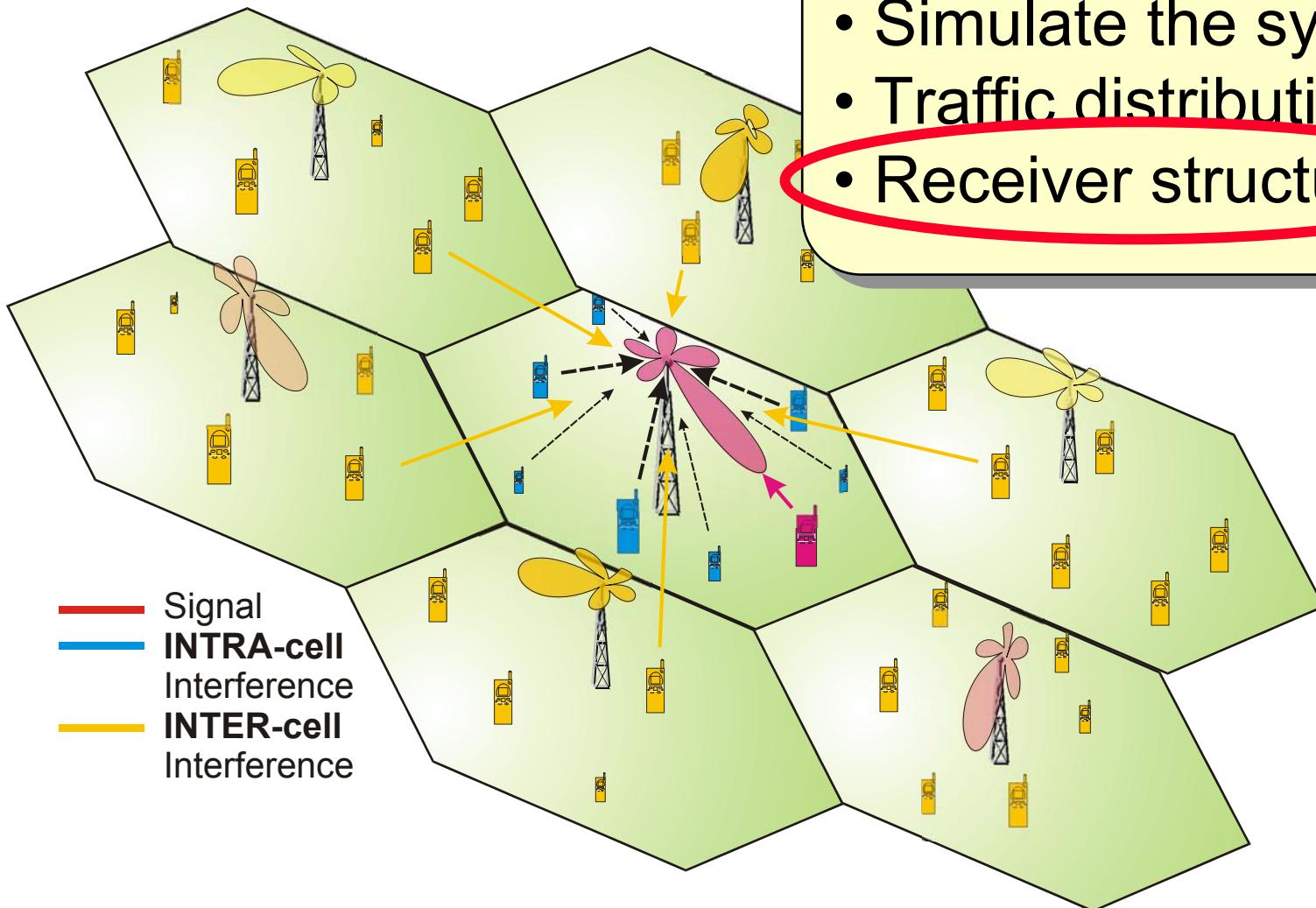
Do we have spatially white interference?

i.e. are interferers equally distributed?

- Interference could be modelled as random process, i.e. white gaussian noise
- Smart antenna gain look-up tables ($f_{\{\text{SNIR}\}}$) could be used for radio network planning

Interference is **NOT** spatially white!

Interference is not spatially white - Consequences



- Simulate the system
- Traffic distribution
- Receiver structure

Spatial Domain

- Channel estimation
- Number of antenna elements
- Algorithms
 - Beam switching
 - Beam steering
 - Maximum Ratio Comb.
 -

Optimum:

$$\mathbf{w}^{opt,S}(\tau) = \operatorname{argmax}_{\mathbf{w}} \frac{\mathbf{w}^H \mathbf{R}^{(S)}(\tau) \mathbf{w}}{\mathbf{w}^H \mathbf{Q}^{(S)}(\tau) \mathbf{w}}$$

Temporal Domain

- Number of Rake fingers
- Maximum Taps
- Rake finger selection
- Algorithms
 -

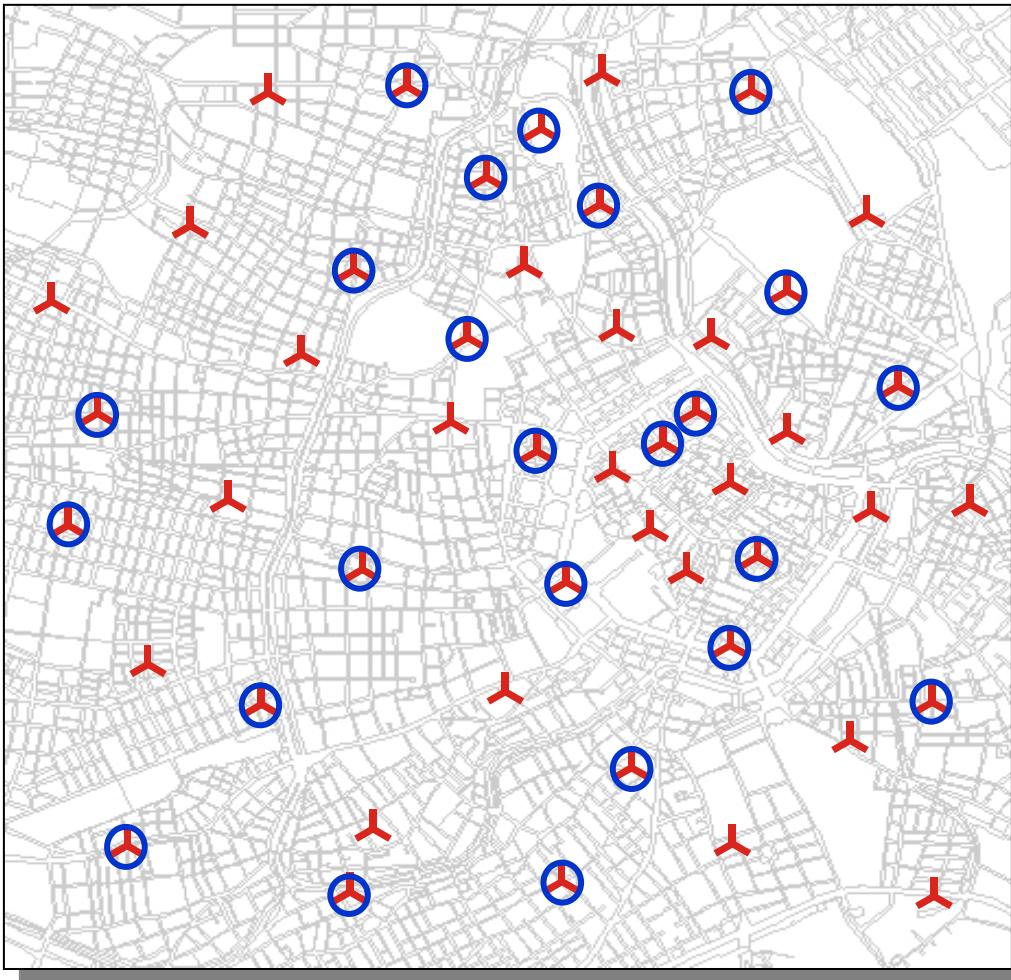
Optimum:

SC/MRC

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- **Planning Example - Results**
 - A planning example
 - Integrated radio planning process
- **Considerations beyond 3G**

Smart Antenna Radio Network Planning Example

City of Vienna, Austria

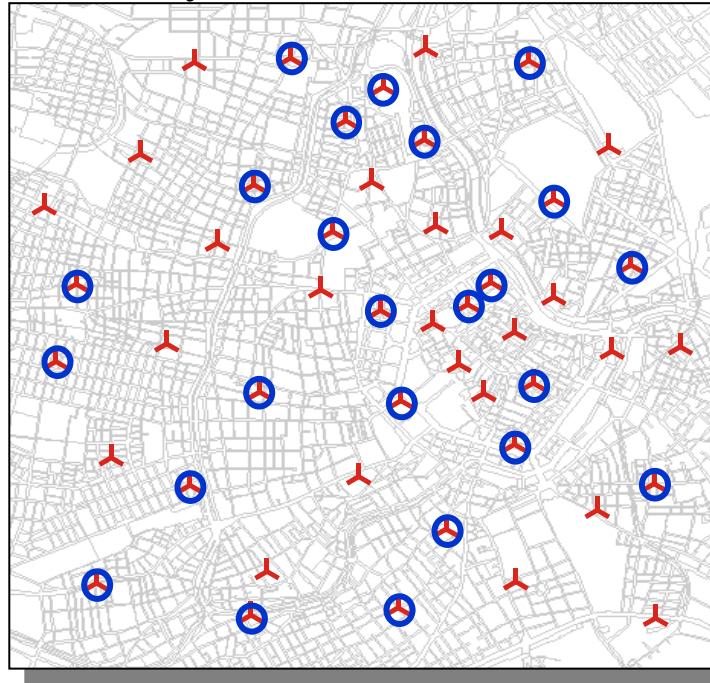


City of VIENNA, Austria

- 144 Cells / 72 “smart” Cells
- Urban propagation model
- Background noise floor of -105dBm
- DOA with 8° rms angular spread
- 1 Antenna (65° Sector)
- 4 Element ULA
- $d=\lambda/2$ inter-element spacing
- Service Mix: speech, 64k, 144k
- UL processing: seq.-space-time
 - spatial processing: opt. Comb.
 - temp. processing: MRC
- DL processing: beamforming
 - UL AoA

Planning Example

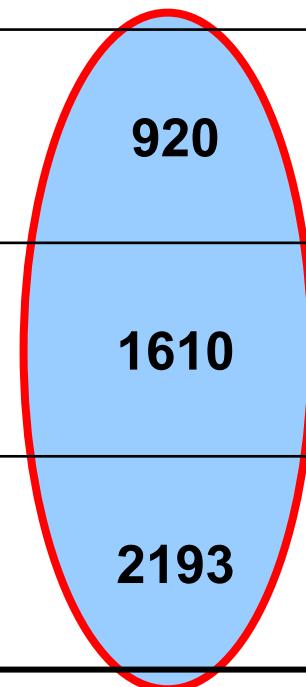
City of Vienna, Austria



- Where do we have bad/no service coverage?
- How does the outage-probability look like?
- Where do we have to invest money?

Capacity Increase

	BS power [dBm]	UL load [%]	Throughput [kbit/s/cell]
Sector antenna	37.4	23.8	920
Smart Antennas No planning	36.0	14.2	1610
Smart Antennas + Radio Network Planning	36.7	19.4	2193



+75%

+36%

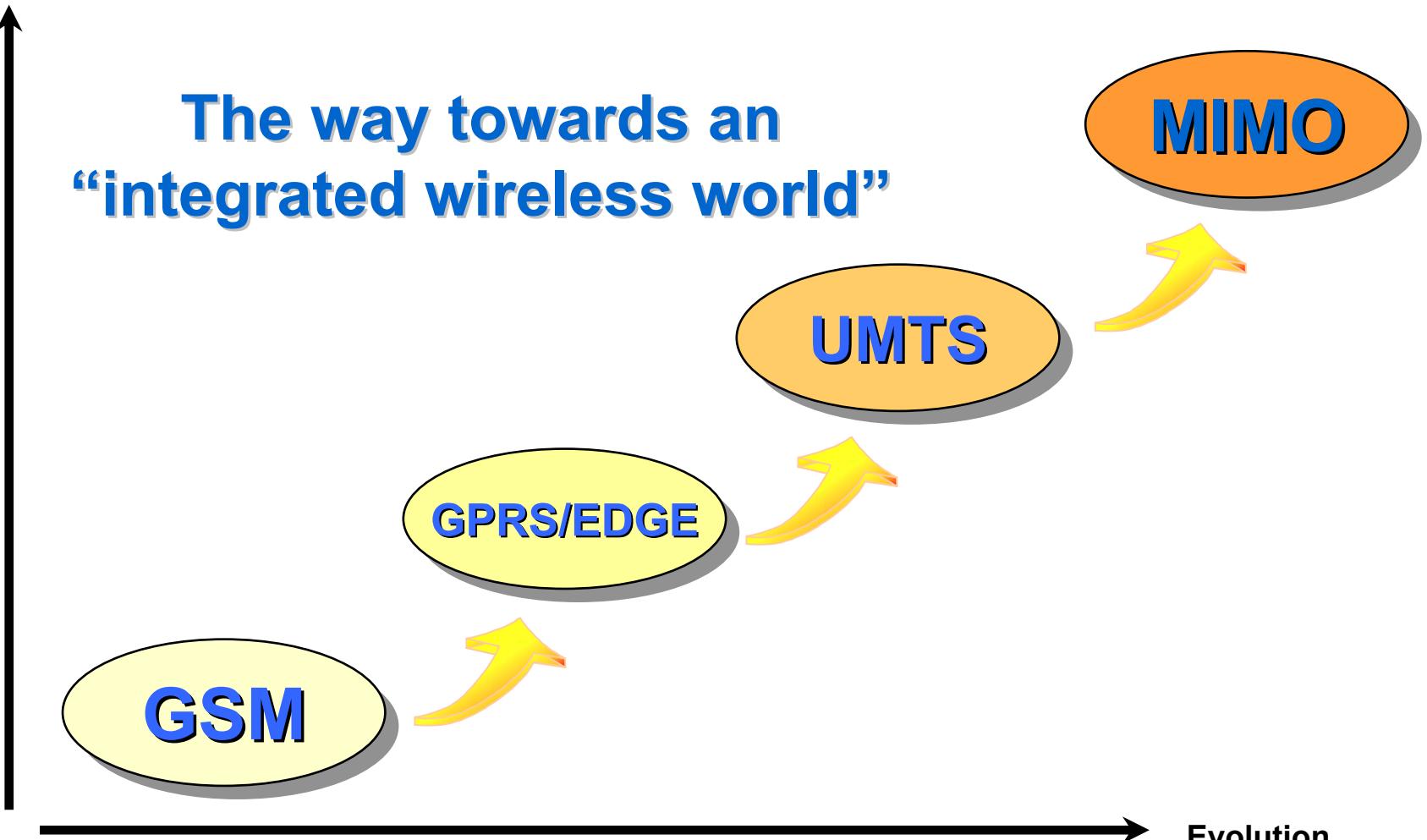
Smart Antenna Radio Network Planning
will boost the capacity by more than 30%!

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- **Planning Example - Results**
- • **Considerations beyond 3G**
 - Smart Antennas beyond 3G – System Evolution
 - Challenges beyond 3G
 - Radio Network Planning Evolution

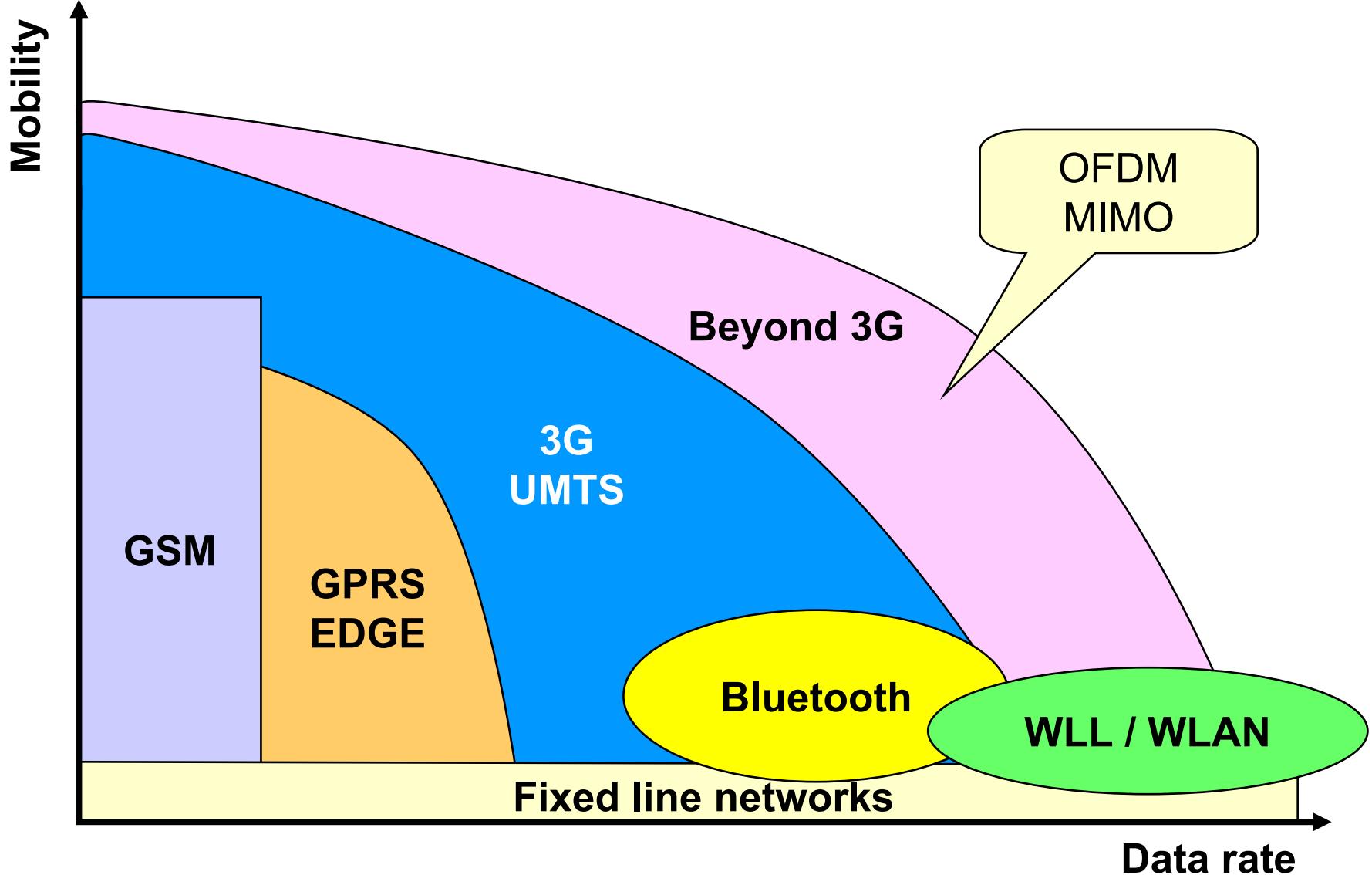
System Evolution

Increasing
Capabilities

**The way towards an
“integrated wireless world”**



Mobile Communications beyond 3G



Multi data rate mix in an „integrated wireless world“



Low data rate

→ Which services?



Medium data rate

→ Where?



High data rate

→ What are the costs?



Very high data rate

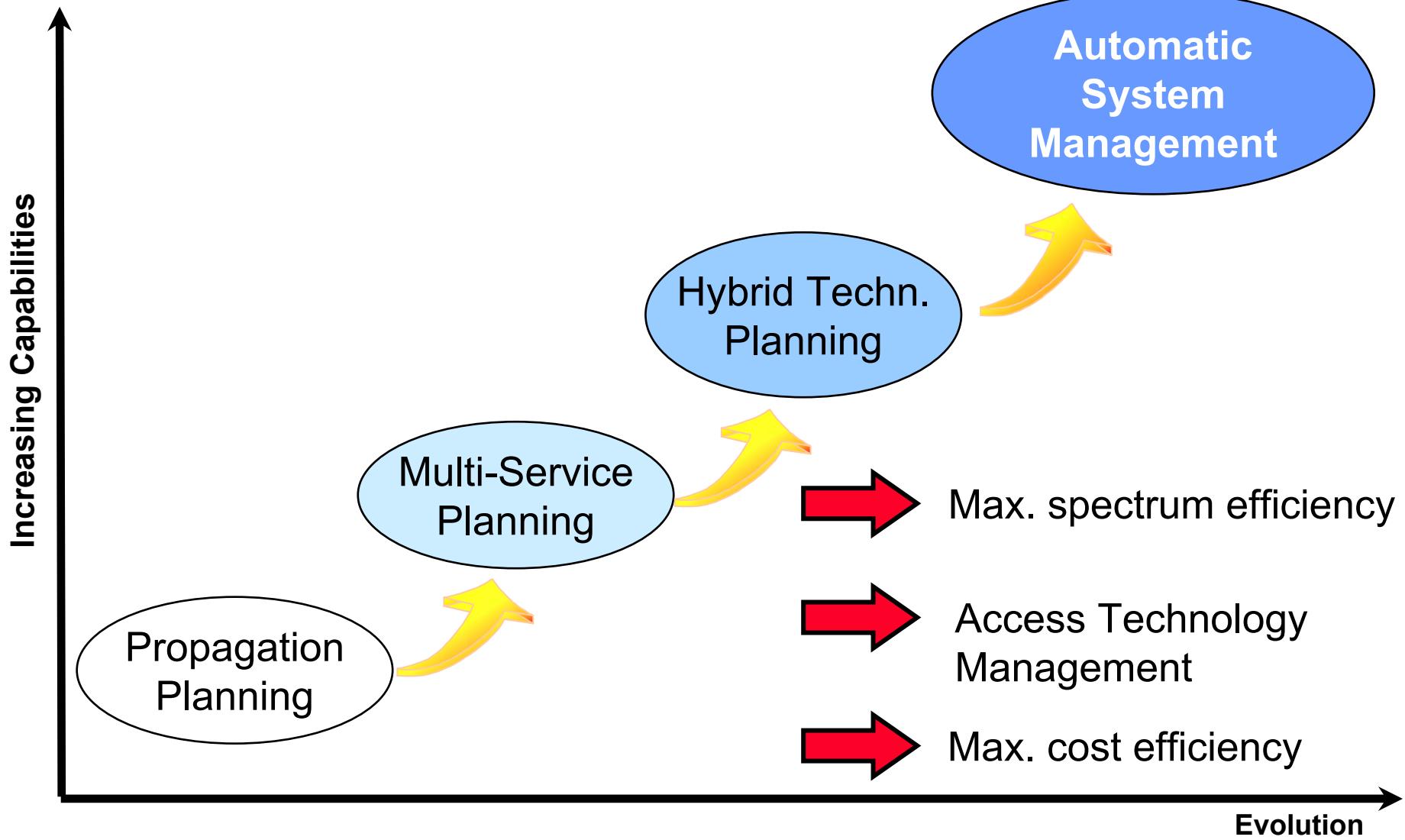
→ What about mobility?

→ Which access technology?

→ Traffic demand?

→ Data security?

Radio Network Planning Evolution



- **Advanced Spatio-Temporal Channel Models are required for Smart Antenna Systems**
- **Smart Antenna Radio Network Planning will boost the capacity by more than 30%**
- **Higher Layer Procedures and RRM algorithms have to be considered**
- **3G and Beyond: Radio Network Planning will be enhanced by Automatic System Management**

Thank you



System Management for Enhanced Wireless Access

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